Neutron Cross Section Measurements at ORELA

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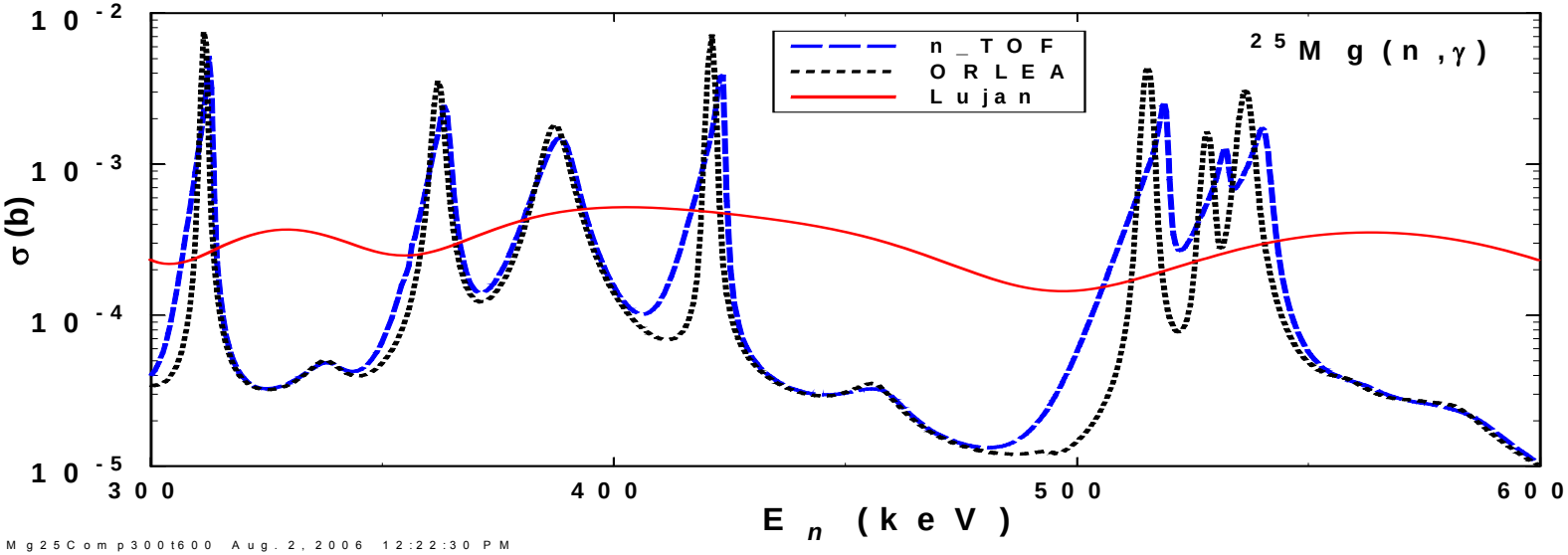
OakRidgeElectronLinearAccelerator

- High flux (10^{14} n/sec) => gram-sized, affordable samples
- Excellent resolution (Δt=2-30 ns) => good S/N facilitates better evaluations
- "White" neutron spectrum from E_n ~ 0.01 eV - 80 MeV => reduces systematic uncertainties
- Measurement systems and backgrounds well understood => very accurate data
- Simultaneous measurements => (n,γ), (n,α), (n,n'), (n,f), and σ_{total} experiments at the same time on different beam lines
- Measurements on over 180 Isotopes: ORELA measurements have contributed to ~80% of U.S. Evaluated Nuclear Data File (ENDF/B) evaluations

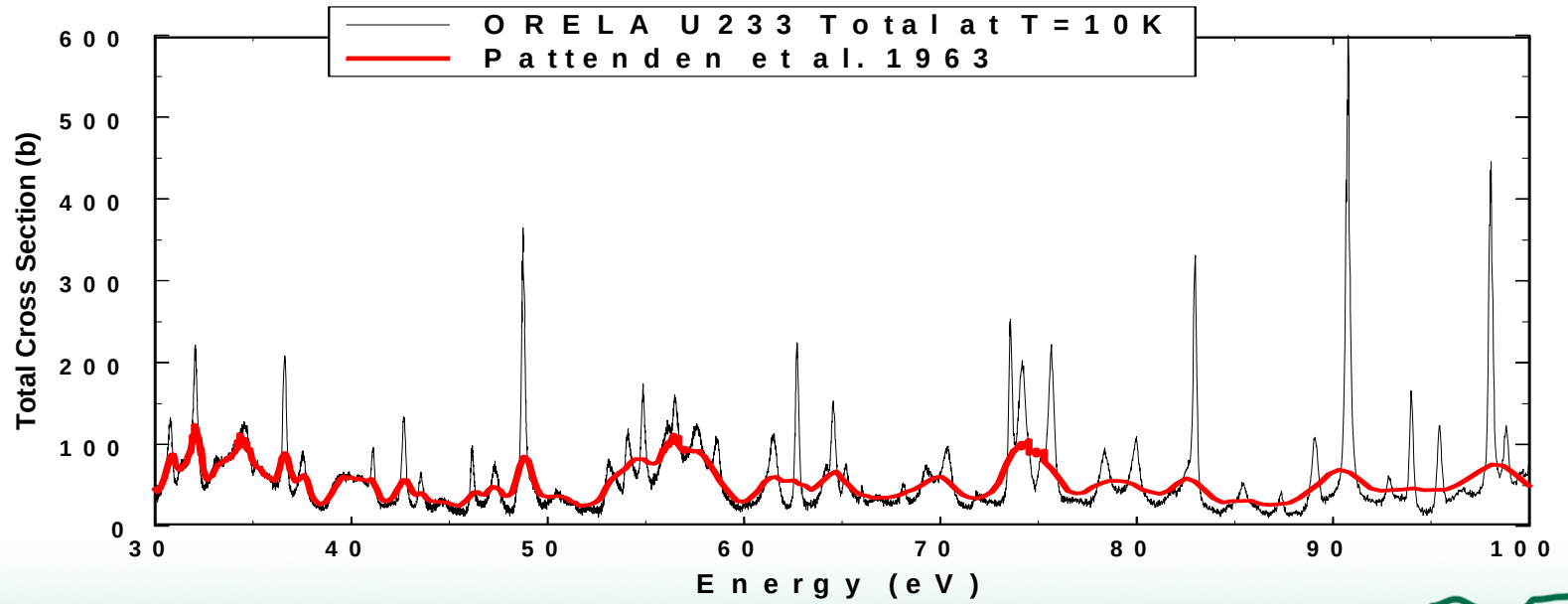
Neutron Cross-Section Measurements in Resolved Resonance Region

- Flight path length, the longer the better
- Pulse width of the neutron burst, the shorter the better:
  - Typically fixed with spallation sources (tens of ns to hundreds of ns)
  - Linac sources can vary pulse width (1ns up to tens of ns)
- Source moderation distance
  - Uncertainty of the creation location of the neutron inside the target/moderator configuration impacts resolution
  - ORELA has relatively small neutron production target
  - Spallation sources are usually optimized for thermal neutron flux, this requires large moderators
    - The moderation effect places tails on resonances due to delayed neutron emission
    - Hinders resolution of closely spaced resonances
    - Produces background in unresolved energy range which cannot be corrected. This effect is on the order of 16% at 20 keV (Coceva et al. 2002) for n_TOF and can not be estimated quantitatively

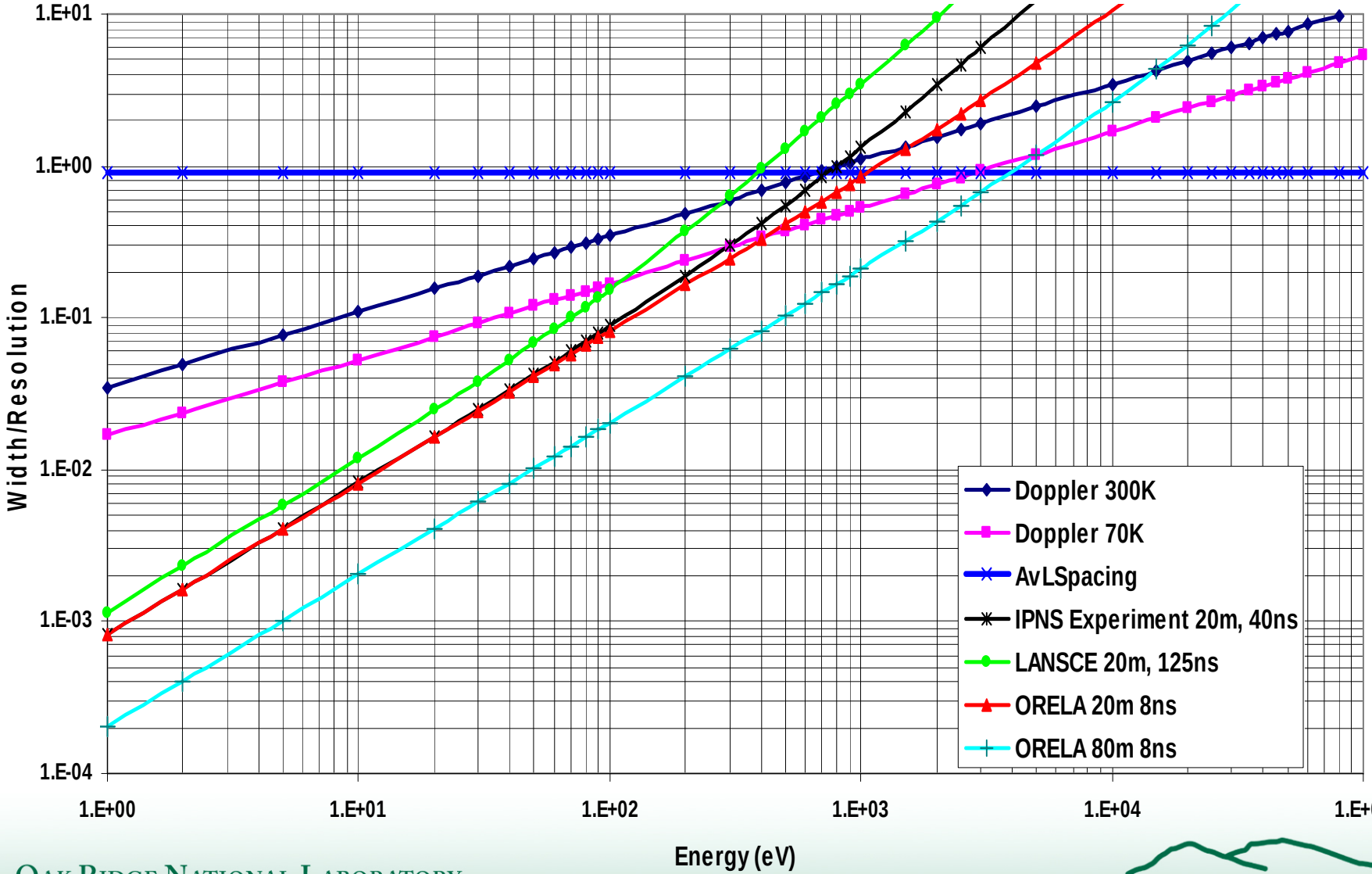
The Influence of Resolution



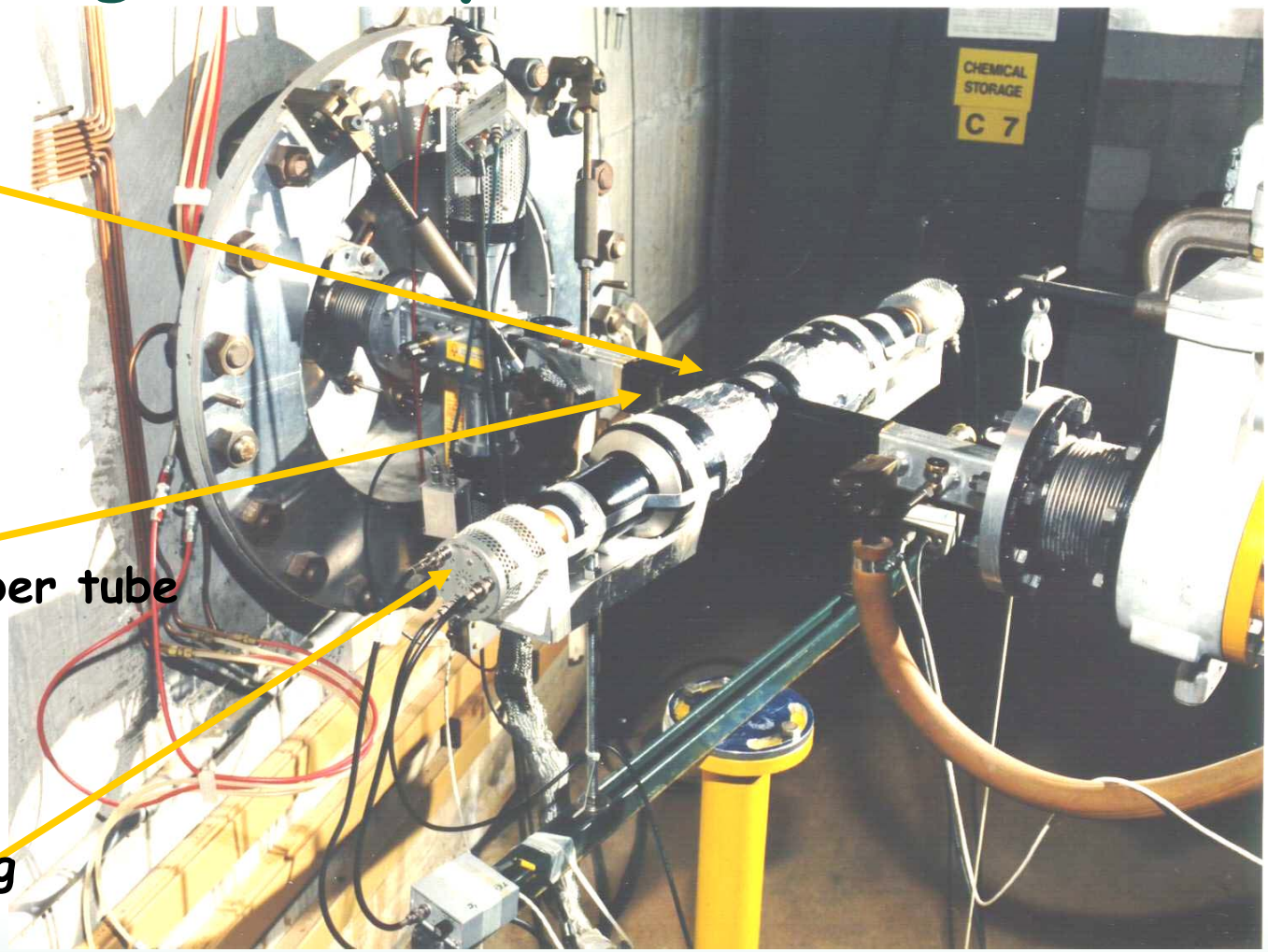
Mg25Comp300t600 Aug. 2, 2006 12:22:30 PM



Doppler - Resolution Broadening @20 m for 241Pu



Modified capture data measurement system has significantly less structure



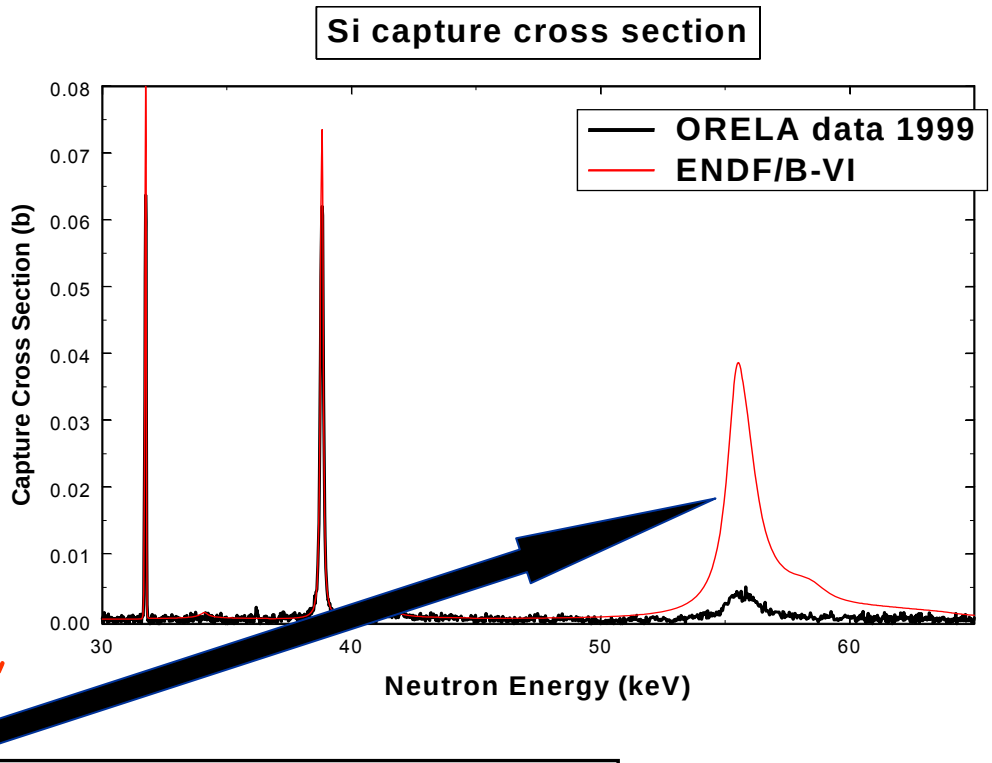
Sample changer replaced

Aluminum guide replaced by C-fiber tube

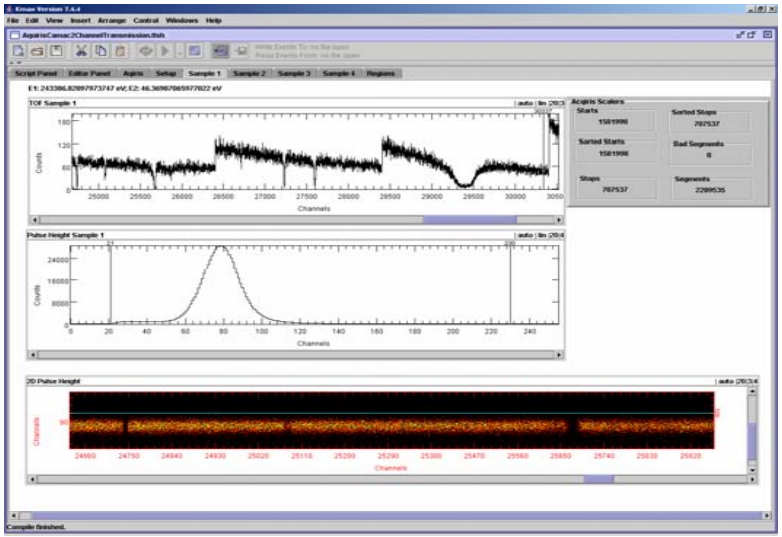
Detector housing removed

Much of the Old Neutron Data (on Which Current Evaluations Are Based) Are Seriously Incorrect

- Some problems with the old data:
  - Underestimated neutron sensitivity correction
  - Low-energy cut off of 3 keV
  - No high energy (>100 keV) data
  - Incorrect weighting function
  - Poor resolution
  - Poorly characterized samples, i.e. water in the sample

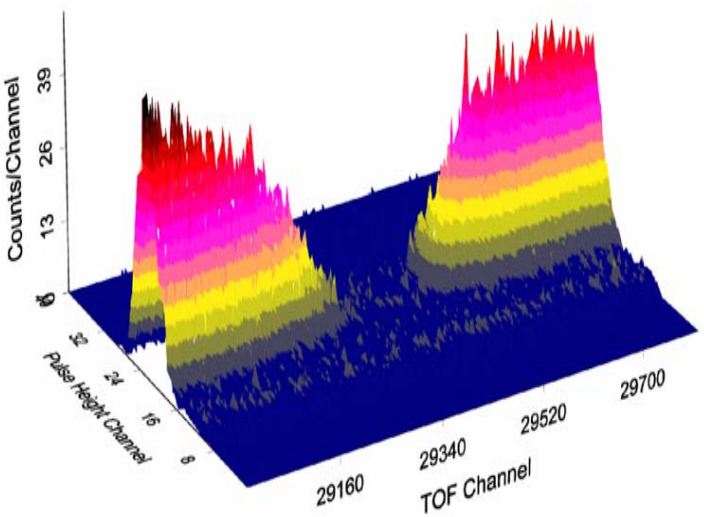


Ex: Large neutron sensitivity of older measurements led to many erroneously-large resonance areas in current evaluations.



New Set-up for Transmission Measurements

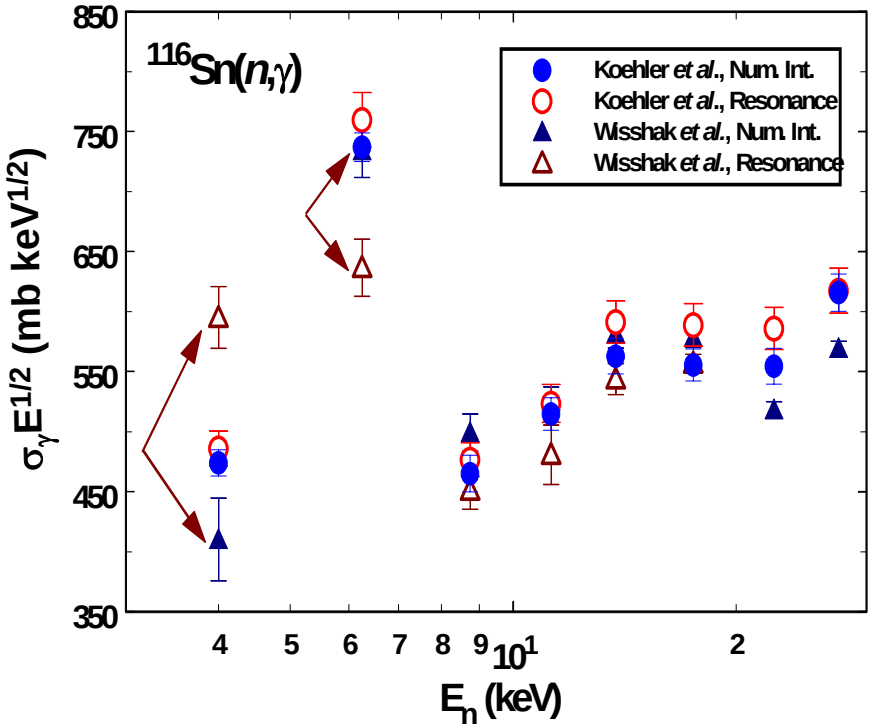
- Time and pulse-height signals are digitized in two channels of an Acqiris digitizer
- Allows to take 2D spectra: Counts as a function of TOF and pulse-height
- Fewer electronic components, thus simpler and more reliable
- Unlimited stops per start
- Easy upgrade path to allow the use of ^{6}Li-glass and NE110 simultaneously in the same transmission measurement. This would allow to cover the whole energy range with the most efficient detector.



2D: Counts as a function of pulse-height and TOF

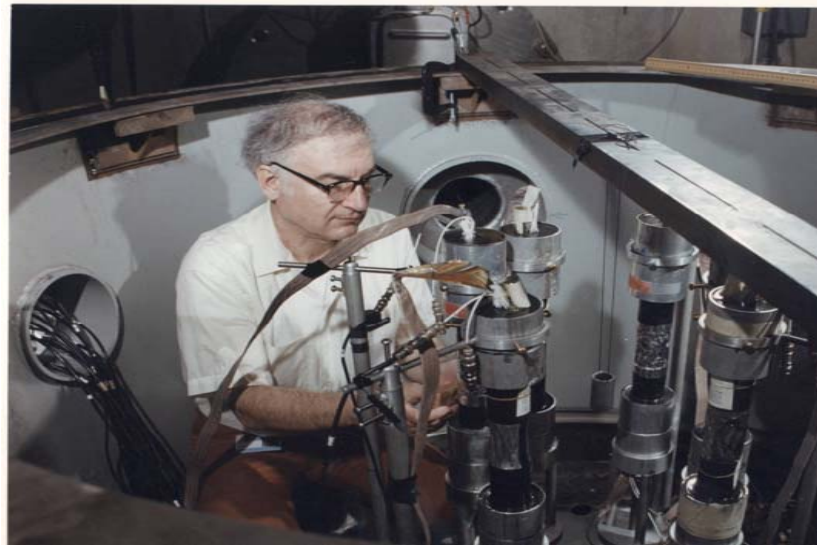
The Importance of Total Cross Section Data

- More complete resonance parameter data will help improve nuclear statistical model.
- Is indispensable for obtaining the most accurate (n,γ) reaction rates. See resonances not visible in (n,γ) data. Improved self-shielding and multiple scattering corrections.
- Lack of good total cross section data can lead to serious errors in these corrections and hence in the cross sections.



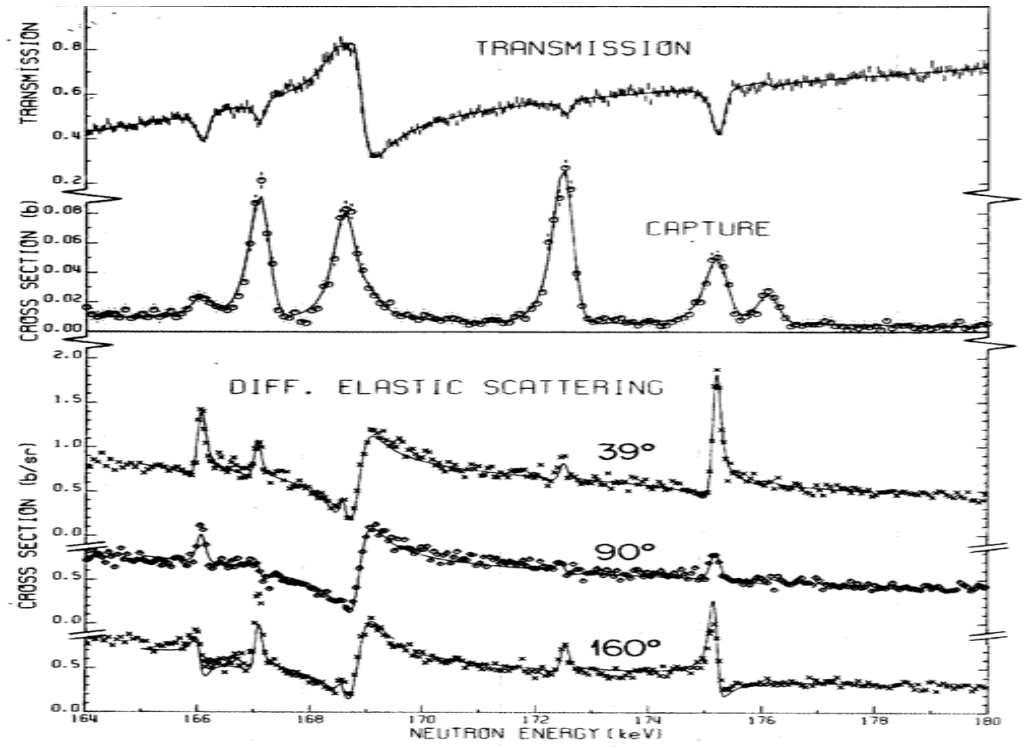
- **Ex: ^{116}Sn Use of incorrect neutron widths led to incorrect low-energy cross sections (Wisshak et al.).**

Elastic Scattering Measurement Capabilities



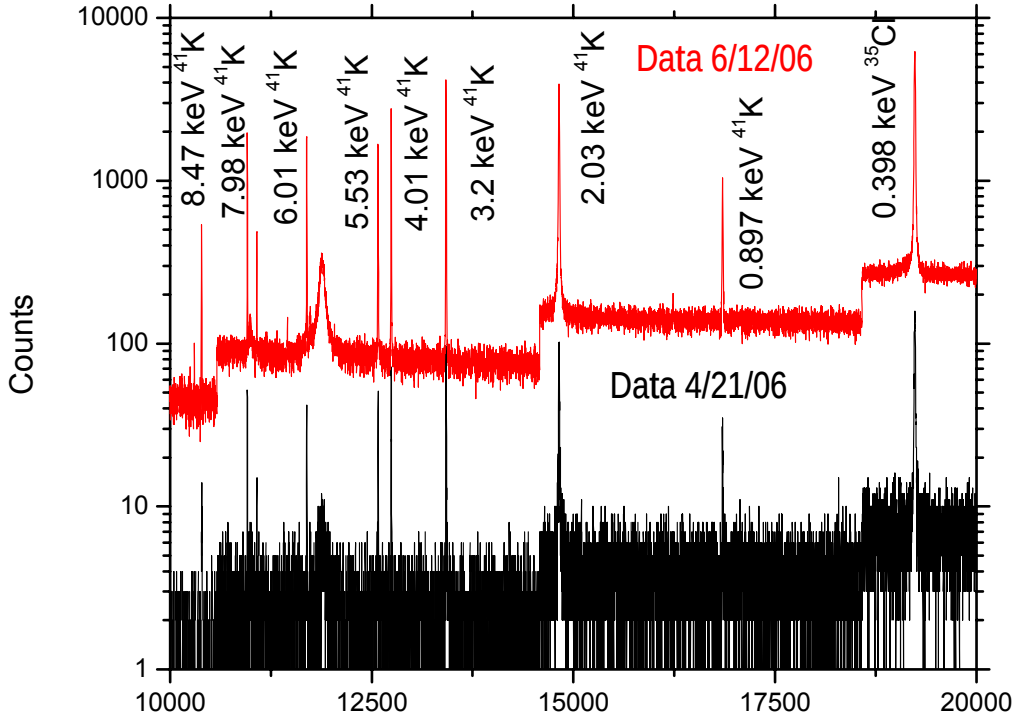
- Scattering Chamber at 200m with six neutron detectors
  - 4.32 cm diameter, 7.62 cm length NE110 cylinder
  - 8850 photomultiplier tubes connected at each end of NE110 cylinder
- Position detectors at various lab angles from target sample located in center of scattering chamber

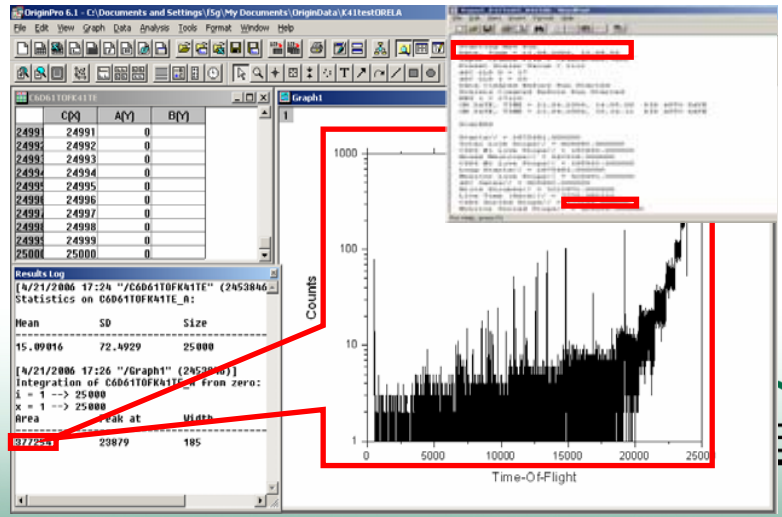
^{58}Ni Measurement and SAMMY Analysis



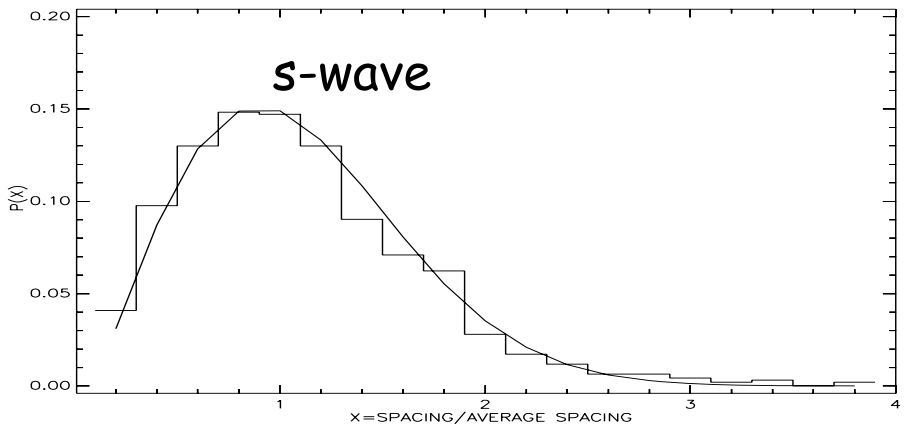
Recent ORELA Measurements

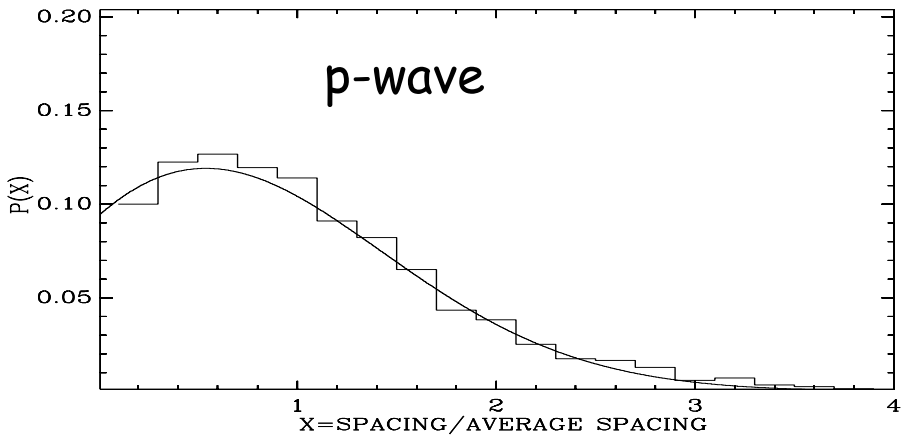
- Use of a 99% enriched ^{41}KCl sample in the neutron beam of ORELA at flight path #7 in the 40 meter flight station
- Beam specifications: 525 Hz, 8 nsec pulse width and 4kW
- New electron gun design performing well
- Able to start/stop accelerator as desired—vacuum holding
- Further improvements in beam power anticipated as the system is fine-tuned
  - **Restarted ORELA April 17, 2006**
  - **~100 hours beam time in last couple months**



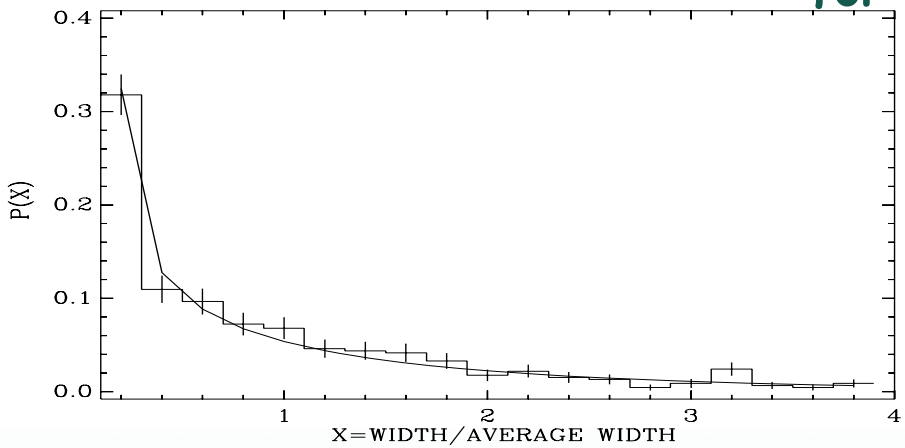


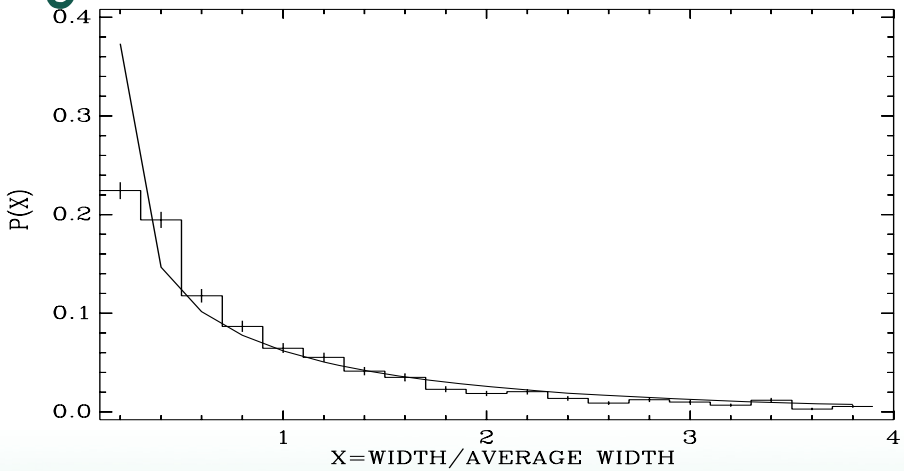
Differential distribution of resonance spacing (Wigner distribution) for ^{238}U



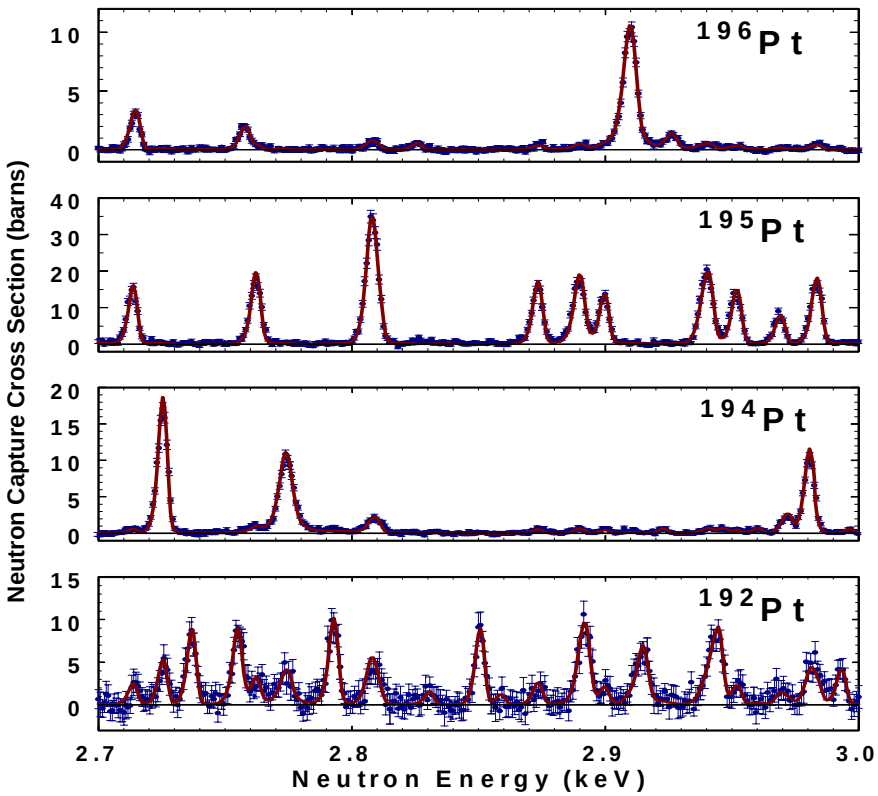


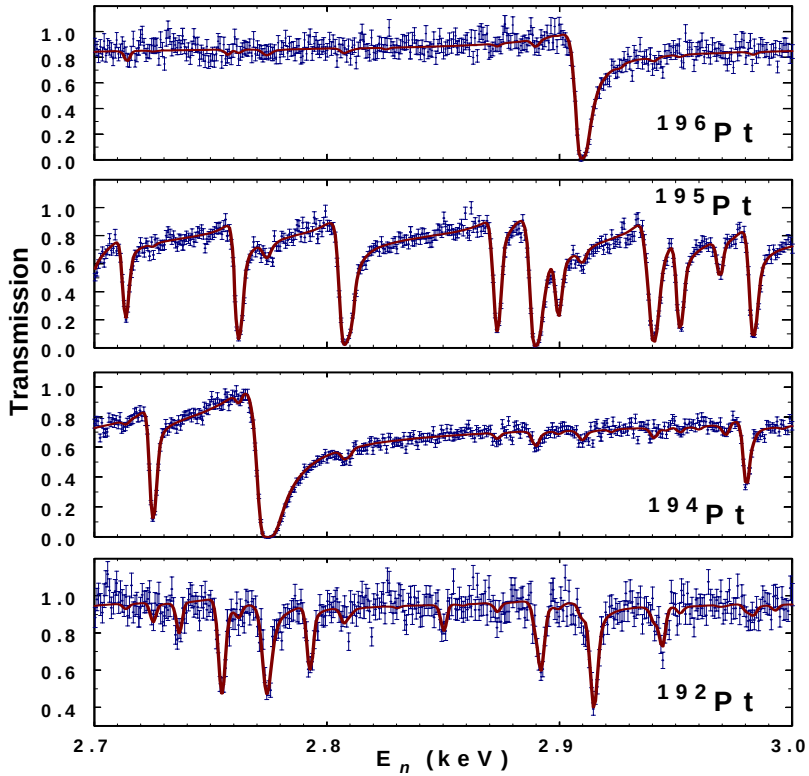
Distributions Of The Reduced Neutron Widths (Porter-Thomas distribution) for ^{238}U





Neutron Capture and Total Cross Section Experiments at a White Neutron Source: Typical Results

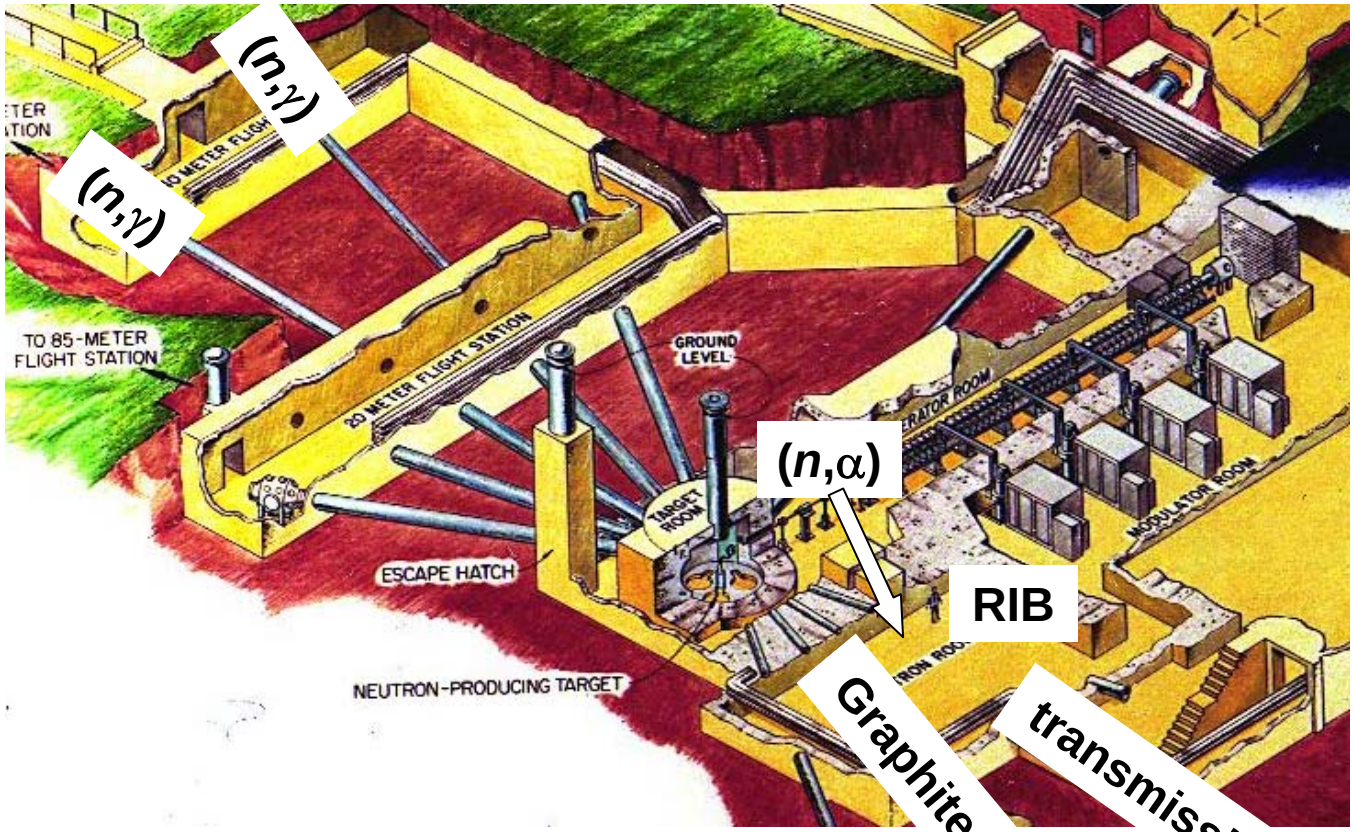




Only small part (0.06%) of energy range of data shown.

Separate sample-out and background measurements needed.

Existing Experiments at ORELA



- 11 Flight paths
- Flight Stations:
  - 8-18, 20, 35, 40, 85, 150, and 200 m